GREASEWOOD (SARCOBATUS VERMICULATUS (HOOK.) TORR.)

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TAXONOMY

Nomenclature. Big greasewood, black greasewood, or here simply greasewood, is a spiny deciduous shrub with simple, fleshy leaves. It is a member of the worldwide goosefoot family (Chenopodiaceae) with 14 genera in the U.S.A. Seepweeds (Suaeda spp.) glass worts (Salicornia spp.) and pickleweed (Allenrolfea occidentalis), all halophytes, are its close relatives. The family formula is $K^5C^0A^5\underline{G}^2$ or $Ca^2Co^0S^{2-5}P^1$ (45,65).

The genus name is derived from the Greek "sarx" meaning flesh and "batos" meaning bramble. The adjective is from the Latin "vermis" meaning worm and "culus" meaning small.

The species is both monoecious and diœcious. The worm-like staminate aments are 0.5-3.0 cm. (0.2-1.2 in long. The pistillate flowers are either solitary or in small clusters. The colorful, winged fruits are 0.8-1.3 cm. (0.3-0.5 in.) long and broad. It is known to hybridize with other goosefoot genera (21).

Greasewood attains heights of ½-3 m. (1½-10 ft.). The wood is hard and strong. The bark varies from yellow to black. It is not to be confused with other "greasewoods", creosotebush (Larrea tridentata) or chamiso (Adenostema fasciculatum), nor with greasebush, (Forsellesia spinescens)(20, 35, 46, 67).

DISTRIBUTION

Greasewood thrives in many associations from Mexico to Canada but prefers the cold deserts north of 37° latitude. It is estimated to cover over 4.8 million ha. (12 million acres), more than any other phreatophyte (64).

Alkali sinks of the Great Basin are encircled by zones of greasewood. It is a minor component of sandhill vegetation of the Mississippi Valley. Neither alkali, salt, nor high watertable are absolute requirements (22). It is found among other succulents of the strand above tide water mark in southern California (3).

When native shrub communities of the sagebrush-wheatgrass (Artemisia sp.-Agropyron sp.) zone are ranked in importance (sic) in southeastern Washington and adjacent Idaho, greasewood stands fifth behind Artemisia, spiny hopsage (Grayia spinosa), bitterbrush (Purshia tridentata) and sage (Salvia sp.) (19). It is the principal phreatophyte, other than riparian, in the shadscale zone of western Nevada (8,43), and the most extensive halophytic type of the intermountain region (7, 12, 54). It forms large colonies on alkali plains of Utah and Nevada with creosote bush, rubber rabbitbrush (Chrysothamnus spp.), and Artemisia spp. It is found at elevations of 300 to 2400 m. (1000-8000 ft.)(5,20). Its range is more extensive than that of big sagebrush (Artemisia tridentata) in western North America (19, 58).

EVOLUTIONARY HISTORY

The origin of greasewood and its first appearance in western America are obscure. Greasewood pollen and grass pollen have been dated as Eocene epoch or 50 million years ago.

The pollen grains of greasewood are quite distinct from those of other Chenopods (40). They have been recovered in small numbers with other pollen samples in the north central states and also by high level air sampling. However, existence of greasewood in the Lake States in recent time is doubtful.

Numerous paleobotanical studies focusing particular attention upon fossils of differenct periods of the Cenozoic era make no mention of greasewood. nor of the Chenopodiaceae (3, 11, 14, 15, 29, 38, 60, 78). Fossil floras of four western states have been catalogued to include 150 species in 37 families without any chenopods (11).

Ecoclinal variation. Taxonomists differ about the number of species of greasewood (76). The dwarf form, which is non-phreatic, darker in color, more pubescent, with broader wings on the fruits is accepted as a species, S. baileyi (6,66). Others prefer Sarcobatus vermiculatus var. baileyi while others insist that no consistent morphological differences warrant varietal status (1). No biochemical or cytological studies are available to clarify this situation.

The "baileyi" form associates with shadscale (Atriplex confertifolia), bud sagebrush (Artemisia spinescens), winterfat (Ceratoides lanata), and other xeric species on well-drained slopes in about 20 percent of Nevada and in adjacent California (6).

DEVELOPMENTAL HISTORY

The gametophyte chromosome number most common in Chenopodiaceae is 9 (77). The number in greasewood is believed to be 18 (4, 21). Tetraploid and Octoploid populations have also been reported (9).

A great deal of information is lacking about the ontogeny and phylogeny of greasewood. More is known about its phenology (57).

Seed cast appears scanty when compared with associated shrubs. Wind and gravity are evidently agents of pollination and seed dispersal, as indicated by the broad wings on the achenes, especially of the "baileyi" form. Staminate flowers are high on the plant and pollen production is lavish (72).

Greasewood seeds germinated well at constant moderate temperature 11°C (52°F) in 5½ days. All higher temperature regimes inhibited germination; for example, at constant 26°C (79°F) 98% of the seeds failed to germinate while 2% did germinate in 3 days. Seeds subjected to an 8 hr./16 hr. alternating temperature pattern were devitalized 80% by a "day" temperature of 26°C (79°F).

Seeds responded to moisture stress above -10 bars by slower but not significantly lower germination even at -16 bars. Light was not found to influence germination (58a).

Reproduction by seed, in the writer's opinion, is much less common than among many of its co-dominant shrubs, e.g. sagebrush, rabbitbrush, or saltbushes (Atriplex spp.). Most often, upon examination, juveniles prove to arise from adventitious buds in roots that have been exposed or mechanically injured. These young shoots are herbaceous and succulent. They elongate rapidly and sometimes produce seed the first year (17). "Halogeton looks like baby greasewood" (2).

Greasewood sprouts readily from its crown or its widely spreading roots. The deep taproot has been traced to 5.7 m.(to 19 ft.). Coarse roots at 0.6-0.9 m. (2-3 ft.) have been found associated with 4-5 m. (15 ft.) taproots (10, 24, 34).

Reproductive development and vegetative growth of greasewood in 5 stands of different densities, cover percentages, and in different association on 5 different soils have been studied recently. Twig elongation of 1-2 mm. per day occurred in June, about at the time of the opening of the staminate spikes. Seasonal stem elongation ranged from 7-10 cm. (3-4 in.) (57).

The rate of accumulation of phytomass has not been sufficiently measured. Shrubs in a particular habitat type tend to stabilize at a uniform height and spacing.

Longevity of greasewood may be assumed to be great for two reasons. It regenerates the shoot system rapidly after removal of same. Individual bushes frequently stand on hummocks or mounds created by wind erosion and deposition of soil and litter, presumably over a long time.

ECOLOGY

If greasewood is considered in its relation to light, temperature, and soil moisture, it is seen to be narrow in its light tolerance, wide in hardiness, and sensitive to presence and changing levels of ground watertables.

Greasewood has relatively few competitors for light, owing to its stature and osmotic pressure. Its shade is too thin to suppress subdominants.

Greasewood communities are most common in valley bottoms which have extreme maximum and minimum daily and annual temperatures. Soil surface temperature exceeds 71 C. (160°F.) briefly in July and August afternoons in such areas.

The common associates of a species are useful in understanding its ecology. Greasewood is regularly a dominant with subdominant grasses, e.g. wildryes (*Elymus* spp.), Indian ricegrass (*Orzopsis hymenoides*), squirreltail (*Sitanion hystrix*), saltgrass (*Distichlis stricta*), alkali grasses (*Puccinellia* sp.), dropseeds (*Sporobolus* spp.). Winterfat and several saltbushes are common subdominant shrubs. *Bassia hyssopifolia* is a palatable forb of alkaline soil often present in these communities.

The maximum biomass of greasewood in relation to site characters is unknown. However, it is apparent that its leaf retention, height, and density respond to the levels and fluctuations of the ground water (43). Where greasewood roots cannot tap the capillary zone, the shoot tends to assume the dwarf "baileyi" form commonly associating with shadscale. Wolfberry (*Lyceum cooperi*) is an associate here (19). These well-drained communities sometimes extend onto captured dunes bordering alkali playas (17).

During recession of Great Salt Lake in the drought years of the 1930's, greasewood was observed creeping out on the playas (26).

Seasonally water may pond on the surface and evaporate without adding to the watertable, or to the root zone in tight sodic clay. Infiltration rates consistently less than 0.25 cm. (0.10 in.)/hr. have been measured in the barren interspaces. This was in contrast to 5.1 cm. (2 in.)/hr. in the hummocks or coppice dunes crowned by greasewood. The rates were associated with exchangeable sodium percentage levels (56).

Edaphic Relationships. Agricultural development and need for information for land use planning occasioned several classic pioneer studies of soil-plant relationships in greasewood and adjacent communities (12, 16, 42, 61).

Greasewood has a wide range of tolerance for saline and alkali soils (28, 47). Soils under greasewood in salt desert in Utah contained a higher exchangeable sodium content and higher pH (9.25-9.83) than those under any other associated shrub (24, 50, 53). Not all studies support this finding (56). Tissue salt content was 157% as much as in Nuttall saltbush (Atriplex nuttallii) and 93% that in shadscale.

Distribution of greasewood is believed to be related to the amount of exchangeable sodium and the percent of water retained at field capacity (13). Salt content of soils in greasewood communities is found to vary from 500 to 16,000 ppm. (0.05%-1.6%)(54). The plant was found to grow in a zone of average maximum soil moisture stress of -70 bars. Massive zonal communities were mapped in the western half of Nevada, western and eastern thirds of Utah, northern Wyoming, southeastern Oregon, southwestern Idaho, and southern California (10). These zones are typically between zones of saltgrass and sagebrush (18).

In S. E. Washington cheatgrass (Bromus tectorum) was seen to grow more luxuriantly in higher density in greasewood interspaces than in adjacent interspaces between big sagebrush (Artemisia tridentata). Sampling at dm. (4-in.) intervals to 1 m. (3.3 ft.) throughout the year revealed that the increase in available moisture in the greasewood soil exceeded that in the sagebrush in the 4 upper dm. (16 in.). This occurred despite a higher percolation rate in the sagebrush interspaces. Less transpiration by greasewood, owing to its leafless winter condition, contributed to a favorable moisture relationship whereas the evergreen sagebrush preempted the scanty accumulation. The shallow-rooted cheatgrass was not inhibited by the higher salinity and exchangeable sodium below 2 dm. (8 in.) (51).

High concentration of boron was found to be a factor in preventing colonization of greasewood interspaces (56).

A soil supporting greasewood and salt rabbitbrush in northern Nevada was classified as a "mixed (Calcareous) mesic Aquic Durorthidic terriorthent" (17). Another greasewood soil in northern Nevada was classified as "a member of a fine-loamy, mixed, mesic family of Typic Camborthids" (62). While greasewood tolerates tight sodic clays and very weak drainage, it thrives in sand. Among the largest plants are those on dunes with less than 0.1% salt content in the first 3 dm. (1 ft.) (34). In a greasewood-rabbitbrush site in northern Nevada, the watertable was at 2.9-3.0 m. (8-10 ft.). The soil texture of small hummocks was loam to very fine sandy loam, whereas soil in barren interspaces was finer, being silt loam to loam. At 0.3-0.9 m. (1-3 ft.) the siliceous duripan permitted root passage when moist (56).

Vegetation analysis of sites on clay and clay loam soils in Utah where greasewood comprised 45% of the vegetation found few associates - commonly five. The greasewood plants were 0.9-1.2 m. (3-4 ft.) tall with a density of 5200/ha.(2100/acre). Vegetal cover ranged from 4.4%-29.5% (22).

Chemical changes in the soil profile are directly caused by greasewood (53). When greasewood and sagebrush grow in mixture in natural communities, the basicity is higher under the former. Where growing in separate communities in central Utah the soil pH was 7.36 in sagebrush and 9.21 in greasewood (12). Around Great Salt Lake it is an indicator of black alkali, sodium carbonate and moist saline soil (26).

Soil moisture and chemical tests in a greasewood-sagebrush community revealed both higher moisture and higher sodium contents under greasewood than under sagebrush (48).

Fire Response. One record of response to fire is available from northern Nevada. Stump sprouts were 0.75 m. (2½ ft.) tall in the third year after wildfire. Return to full vegetative structure was predicted to require 5-10 years (62).

Biotic Relationships. Suitable habitats for mammals, birds, reptiles and invertebrates are found in greasewood communities. seventeen species of mammals, 37 of birds and 111 of invertebrates were recorded in Utah. Insect populations were similar to those in sagebrush communities (22, 72, 74).

In west central Utah greasewood communities on sandy soils, including captured dunes, are favorable habitats for as many as nine species of rodents. The loamy mounds formed by the shrubs are usually perforated by burrows where seed and leaves are stored (74).

The pests and diseases of greasewood appear not to have attracted scientific attention. Old bushes are usually highly interspersed with dead branches, or shoots, possibly caused by insects or lower organisms.

Higher herbivores rarely injure greasewood because of its armor and frequent presence of more palatable forage. However, it is food for the Zuni prairiedog, painted and western chipmunks, jackrabbit and porcupine (74a).

Interspecific competition in greasewood communities is circumstantial, considering the wide interspacing and paucity of vegetation between shrubs. A vigorous growth response follows release from competition. Higher seed production and a prolonged growth period resulted (57). Subdominant species tend to be more abundant under the shrub canopy in the surface litter. This observation of mine appears to contradict the records of salt accumulation from leaching of litter. Shade, litter, and wind deposits may be compensating factors.

PHYSIOLOGY

The ability of greasewood to survive several weeks of flooding or ponding while behaving normally as a phreatophyte suggests that its roots have capacity for anaerobic respiration. However, it is by no means a hydrophyte, shown by its demise when the watertable stands at the surface, doubtless a function of time and temperature (36).

The efficiency of greasewood in carbon assimilation, reserve food storage, and rates of biomass accumulation have not been reported.

Seven elements tend to concentrate in greasewood organs. Samples of greasewood tissue analyzed at Malad, Idaho, contained higher concentrations of sodium, potassium, chloride, sulfate, calcium, magnesium and boron (in order of diminishing quantity) than the soil in which it was growing. Although the leaves contained the greatest concentration, the woody parts still contained more of these elements than the underlying 7.6 cm. (3 in.) depth of soil (54).

CHEMICAL CONTROL

Physiology of growing plants is subject to many chemical disturbances. Foliar application of herbicides has often not been an effective method of control (44). However, recent investigations have disclosed that a kill as high as 72% is possible by spraying a mixture of 2,4-D (2, 4-dichlorophenoxy acetic acid) and Picloram (4-amino-3,4,6-trichloropicolinic acid). Careful attention must be given to phenology and soil moisture content. Higher resistance was encountered near the initiation and end of active growth and depletion of available moisture. Resprouting shoots are most susceptible. Respraying with 2,4-D at a rate of 3.3 kg/ha. (3 lb./a.) gave 92-100% control (17).

ECONOMIC CONSIDERATIONS

The economic roles of greasewood are principally as an indicator of land use potential and as range forage. The values range from positive to negative depending upon use or need.

Land Use Indicator. From the beginning of western settlement greasewood has been considered a reliable indicator of the agricultural constraints of the land (27, 68). It thrives on both saline and sodic soils. Big greasewood sites are more amenable to use than are the drier "Bailey greasewood" lands. However, preparation for cultivation usually requires deep drainage and much leaching by repeated irrigation.

In dry saline sites available water at considerable depth is reached by the taproot (34, 54, 70). In Big Smoky and Steptoe valleys of eastern Nevada, zones of greasewood are underlain by watertables seldom at more than 10.5 m. (35 ft.), but in some places at 15 m. (50 ft.)(42). Attempts to establish grasses by clearing greasewood and irrigating from shallow wells have not succeeded (56).

Nevada research revealed annual evapotranspiration of 3650 to 4260 m^3/ha.(1.2-1.4 acre ft./acre) near Winnemucca with the watertable adjusted at 1.8-2.3m.(6-7½ ft.)(55). In Escalante Valley, Utah, the E/T between May and October was 61cm.(24 in.) from a watertable 71 cm.(28 in.) below the surface (75). Elsewhere seasonal transpiration alone was recorded as 6.6. cm.(2.6 in.)(70).

Range Forage. Generally greasewood alone or with codominant rubber rabbitbrush is regarded as of slight or no value as forage (56). Among California browses its value for sheep and goats is good, for deer poor, for cattle fair to poor, and useless for horses (59). Utilization is restricted by the presence of strong, sharp thorns. Nevertheless, in the Great Basin it is locally a valuable browse (35).

Laboratory analysis of summer and fall samples in Arizona showed protein 21%, nitrogen-free extract 39%, crude fiber 19% and ash 18% ((5). The leaf ash tends to be high in sodium and potassium, e.g. 24% and 22%. respectively (2). Leaf samples in summer in Nevada contained 15.4% crude protein and 0.83% extractable oil (39).

Utilization of greasewood on winter range in Montana was compared with that of sagebrush, winterfat and shadscale. Three intensities of utilization were studied. Under heavy utilization, the descending rank was winterfat, greasewood, shadscale, and sagebrush. Removal of greasewood twigs was 56% at 546 m.(600 yd.) from water and 10% at 1092 m.(1200 yd.)(33).

Chemical analysis of greasewood forage during winter in Montana revealed it to contain 8% to 9% crude protein, which was lower than that present in sagebrush, winterfat or shadscale. At the same time it ranked lowest in phosphorus, having declined to 5 mg. /gm.(0.5%) by late winter (33). However, it is more heavily grazed in the winter when more inviting forage is less available.

In addition to a reduction in food value in the winter, greasewood also is potentially mechanically injurious to browsers. Protein supplementation on the range magnifies the danger. Hungry sheep are at particular risk in greasewood communities. If 0.68 kg. (1½ lb.) of leaves are consumed in a short time, depression, kidney lesions, and death may result. Bovines are relatively safe under the same conditions because of their lower preference (25, 32). Nevertheless, the oxalate content has resulted in death of cattle and horses as well as sheep. Oxalates tend to concentrate in the foliage as it matures. Soluble oxalates in leaves on a dry weight basis range from 10% to 22%(37, 41, 69).

Other Economic Uses. The wood is hard, fibrous and green. The Hopi Indians, despite the thorns, used greasewood for fuel and as dibbling sticks (31, 35).

Its potential for fuel is of interest. Using a sample collected by the author the University of Nevada, Reno, animal nutrition laboratory found that its dry wood yielded 5262 Kcal/kg.(9491 Btu/lb.). Ash was only 3.82%.

A growth ring technique for estimating the biomass of sagebrush-grass sites has been proposed (63). It may be applicable to greasewood sites.

An active research program seems warranted to learn the potential of greasewood and associated shrubs for generation of energy. Prime stands must be mapped and relation of cover to biomass and to energy content must be determined. Remote sensing techniques for mapping could be used (63).

A method has been reported whereby the green biomass of small desert trees can be estimated using linear regression. Stem diameter and height were entered in the cone equation. Factors were derived for conversion to dry biomass (23).

Greasewood on high yielding sites was included in a study of energy biomass in the intermountain United States. The average biomass of large greasewood plants was 44.8 kg.(98.6 lb.) which was higher than other species in the study. Energy value, was 4584 Kcal./m^2 (15206 Btu/yd^2), higher than that of rubber rabbitbrush (*Chrysothamnus nauseosus*). Estimated potential yield was 97,395 kg./ha.(86780 lb./a.) The mature wood of greasewood was higher in energy and lower in ash and sulfur than the young twigs (73).

If harvesting equipment embodying mowers, conveyors, compactors and transport could be adapted or designed, using steam power, greasewood might be a valuable addition to a diversified energy base in the Intermountain West.

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